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(RESEARCH ARTICLE)

A GIS-based assessment of flood impact on agricultural farm activities along river Dilimi, JOS north local government area of Plateau state

Epsar Philip Kopteer [1,*], Olakunle Rufus Oladosu [2], Samuel Adeyemi Samson [2], Jasini Ali Alwadood [2], Olaide Monsur Aderoju [1], Bose Adetutu Ogwurike [3], Michael Nnaemeka Ihenacho [1], James Adah John [1], Philip Okoh Amodu [1], Nkechinyere Gift Nwagwu [1], Chikodili Evans Ezurike [1], Kamila Abba Tukur [1], Augustine Abah Odeh [1], Sumaiyat Abdullahi Kpanja [1], Halimat Ifedolapo Oriola [1], Vivian Aaron Ibrahim [1], Udya Aniya [1], Elizabeth Rizga Jackson [1] and Kikelomo Oluwabukola Adebo [1]

[1] *National Space Research and Development Agency (NASRDA).*
[2] *African Regional Centre for Space Science and Technology Education- English (Arcsste-E), Ile-Ife, Osun State, Nigeria.*
[3] *University of Jos, Plateau State, Nigeria.*

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Abstract

Flood is a natural disaster that impacts lives, food security, and ecosystems. Hence, this study sought to investigate the impact of urban flooding on agricultural farm activities along river Dilimi, Jos North LGA Plateau State Nigeria. The study identified urban agricultural farm activities along River Dilimi, and flood-prone areas along the river, and evaluated the economic impact of flood on farmer's activities in the study area. The study utilized a satellite image of 2021 to digitize urban agricultural farmland along River Dlimi while, DEM, slope, and the landuse of the study area were utilized in an analytic hierarchy process (AHP) on ArcGIS version 10.4 to determine areas prone to flood in the study area. Concerning the economic impact of flooding, the study revealed that loss of farm was ranked 1st, hunger and starvation, loss of properties, and high incidence of poverty with a weighted mean score of 1.22, 1.21, and 1.20 ranked 2nd, 3rd, and 4th while loss of family members, displacement from a natural domain with a weighted mean score 1.19, 1.15 ranked 5th and 6th. Other impacts of floods include damaging roads (1.14), causing malaria (1.13), adding nutrients to the soil (1.11), and causing environmental pollution (1.09). loss of farmland, hunger, and starvation, loss of properties, high incidence of poverty were perceived as serious economic impacts of flood on farmers in the study area. In addition, the result further reveals that river Dilimi covers 1.5%, agricultural landuse covers 2.82%, and other landuse covers 95.66%.

Keywords: Flood Impact; Flood-Prone Area; River Dilimi; Agricultural Activities; Farmland; Vulnerability.

1. Introduction

The [1] defined urban agriculture as the growing of plants and the raising of animals for food and other uses within and around cities and towns, and related activities such as the production and delivery of inputs, processing, and marketing of products. Agriculture plays a fundamental role in providing food for growing populations, raw materials for industries, and support to urban livelihood systems [2]. Agriculture in urban areas usually serves as a means for providing the immediate needs of the people. Agriculture is one of Africa's most sensitive sectors to climate change, with declining agricultural production and an erratic environment that has a substantial impact on food security [3]. The effects of floods on agricultural activities along the river Dilimi and its environment are the focus of this research. Flooding poses a serious hazard to agricultural land in the study area. Flooding has ruined agricultural land, which is the people's main source of income. The principal flood problem in the area is the damage to agricultural land and crops.

* Corresponding author: Epsar Philip Kopteer

During the spring, floodwater overflows the banks of low-capacity channels and inundates thousands of acres of adjacent cropland. Summer rainstorms also produce stream flows over channel capacities that cause sheet water flooding. This flood resulted in serious reductions in agricultural production, which in turn had a depressing effect on the economy of the area. According to [4], river and coastal flooding have the greatest influence on economic flood damage. The subject of flood vulnerability encompasses a wide range of vulnerability descriptors. Flood vulnerability is defined by the United Nations as the degree of damage to a specific object in flood risk zones by a given amount and is present on a scale of 0 to 1. (no damage to full damage). Residents of a flood-prone area, the built environment, or an ecosystem exposed to flood risk are all vulnerable to floods as a result of their exposure, as well as their capacity or incapacity to be resilient, cope, recover, or adapt to the extent of flood damage [5]. Floods are caused by the chance occurrence of extreme meteorological variables, but human actions have an impact on the severity and consequences of floods (Samuels et al., 2017). Flooding can also happen when a channel's capacity is exceeded and water pours out [6]. GIS technology has improved flood management. Simulation, prediction, and assessment of flood effects and impacts may be well mapped using hydro-informatics techniques. With its ability to integrate large amounts of datasets from environmental, technical, economic, and social sources. Coastal flooding of fields can result in crop losses both immediately and over time. Even when floodwaters recede, salt deposition from sea water leaves a legacy of soil salinity [7].

This study aims to assess the impact of urban flooding on agricultural farm activities along river Dilimi in Jos North LGA Plateau State with the Objectives of identifying urban agricultural farm activities along river Dilimi, determining flood-prone areas along the river, and evaluating the economic impact of farmer's activities along the river.

The study is a buffer of 500 meters on the stretch of 14,854.06 m on the river Dilimi between the University of Jos permanent site and the Air Force base. It is located between longitude 8^0 20' and 9° 30'E, and latitude 8^0 30' and 10^0 30' N. It covers an area of 9,400 km^2. It is administratively located within Jos North Local government area of Plateau State, Nigeria.

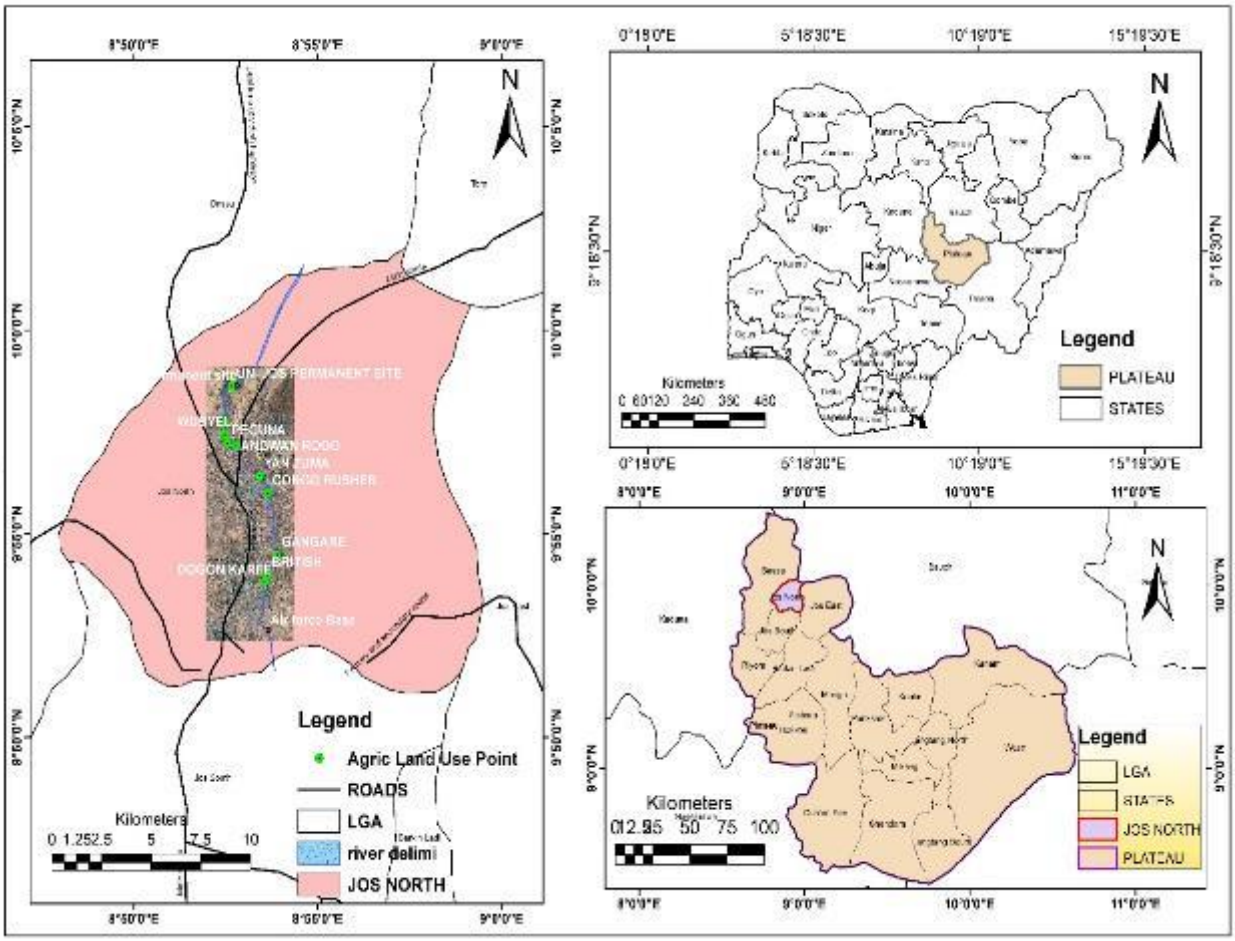


Figure 1 Map of study area

2. Research methodology

This research includes the integration of geographical and non-spatial data, as well as on-screen digitization of obtained data, to conduct a spatial distribution analysis of agriculture along the river. This section of the research discusses data kind and source, data presentation, and analytical techniques, all of which will help the thesis achieve the aforementioned goals.

Table 1 Data type and source

S/N	Data Type	Data Source
1	High-resolution image (0.3 to 0.5meter	Universal maps downloader 9.2
2	River Dilimi shapefile,	www.glovis.usgs.gov
3	SRTM DEM	www.glovis.usgs.gov
4	Rainfall data	NIMET
5	Questionnaires	Farmers along river Dilimi

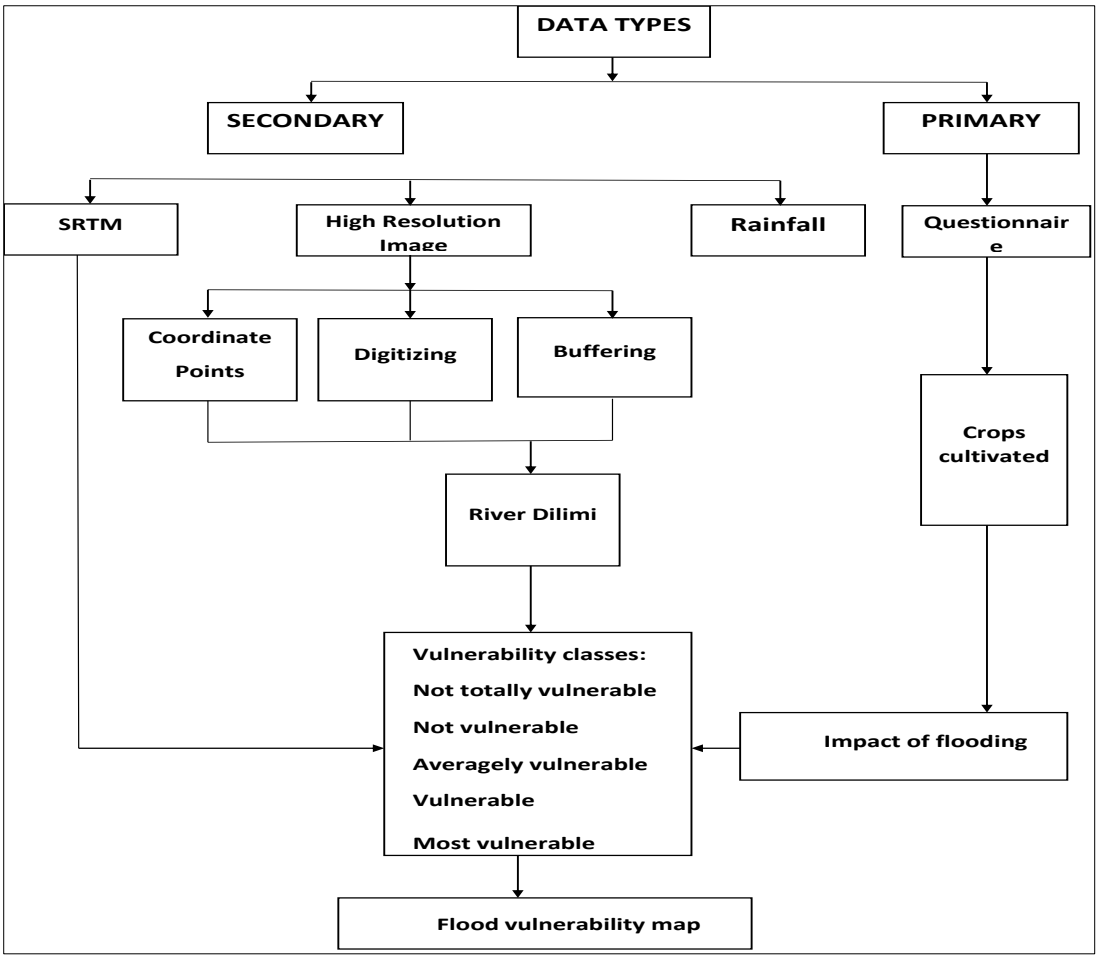


Figure 2 Methodology workflow

2.1. Software Used

The software's used for the analysis include the following:

- ArcGIS 10.4 for digitizing agricultural landuse and flood-prone area analysis.

- Universal maps downloader 9.2
- Microsoft Excel for tables.

A high-resolution satellite image of 0.3 to 0.5 meters was used to visualize the image of the study area. The boundary map of river Dilimi was digitized from Google base map using the ArcGIS software to produce a shapefile for the study area. The 500-meter buffer, agricultural landuse point, and river Dilimi were fully digitized using the ArcGIS software. Digital elevation model data was used for flood mapping and to also determine the attributes of terrain, such as elevation at any point, slope, and aspect or it can be used for digital representation of ground surface topography peaks and pits and other landforms or terrain as GIS data. Jos Plateau state annual rainfall data for three years 2017 to 2019 was obtained from NIMET meteorology stations to determine the rainfall variability and the average mean between the three years to know the month with the highest amount within the year. This information will give us a better understanding of the time of this flood occurrence within the area and it will also help us to put measures in place before its occurrence.

3. Result and analysis

The results of a multi-criteria analysis included flood vulnerability distance from the river and flood vulnerability using the topography of the location.

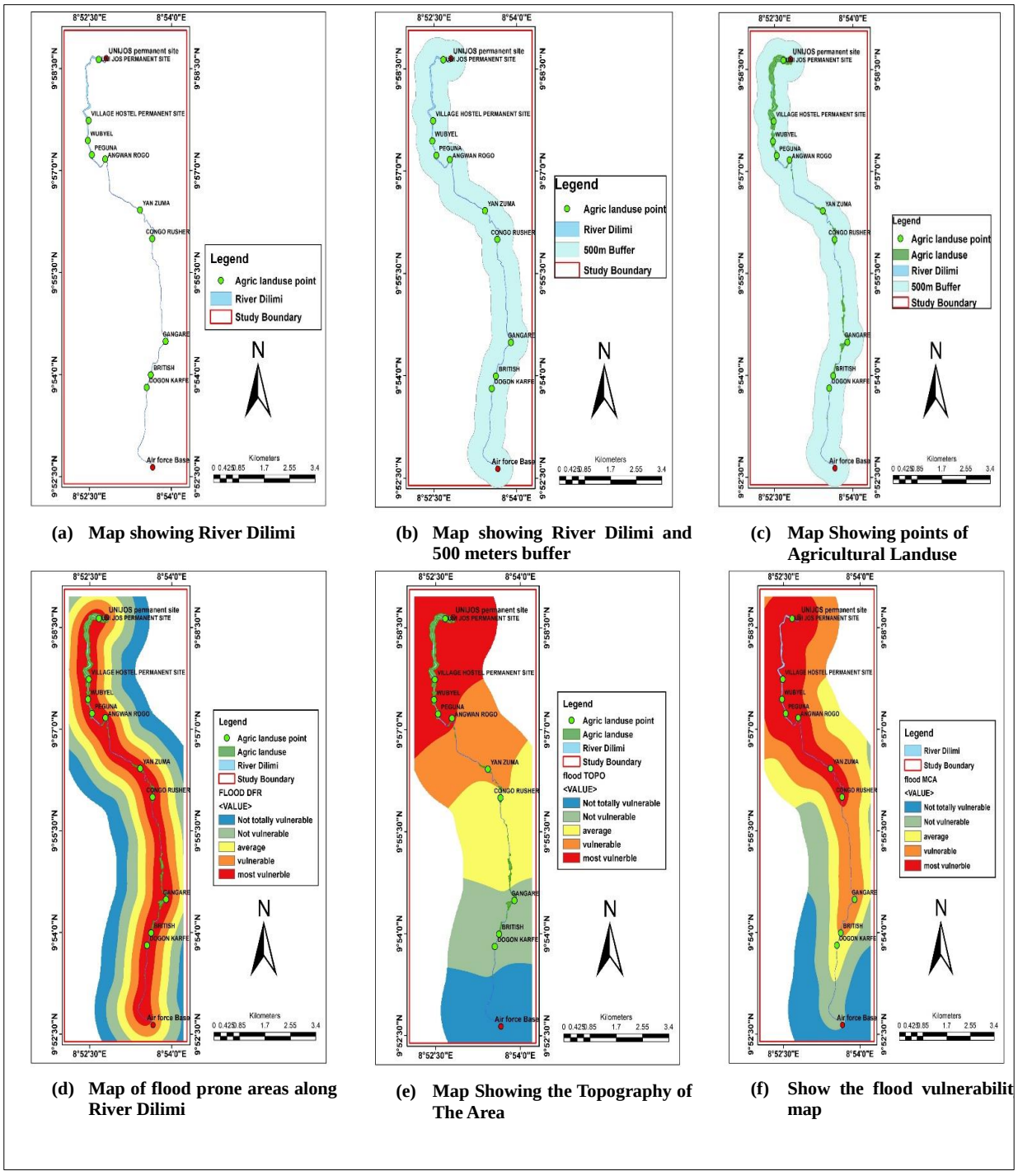
Figure 3 (a-f) represents the flood vulnerability maps of agricultural landuse along river Dilimi. Figure (3a) above shows the length of the study area within river Dilimi with the location along the river while figure (3b) indicates the 500m buffer along the study area with its locations. Studies identify ten agricultural landuse areas along river Dilimi within a 500-meter buffer area of interest as represented in figure (3c) above, figure (3d) shows the Analysis of flood-prone areas within 100m to 500m buffer on river Dilimi, with land within 100m buffer most vulnerable. This affects agricultural activities, food production, supplies, and hunger during rainy seasons. In addition, figure (3e) which is the study area's topography is based on the Air Force Base and the University of Jos permanent site. Places around the base are not vulnerable, while areas along Congo Rusher and Yan Zuma are averagely vulnerable. The most vulnerable areas are between Angwan Rogo and the University of Jos while Figure (3f) which is the flood vulnerability map shows the University of Jos, village hostels, Wubyel, Peguna, Congo Rusher, Gangere, British, and Dogon Karfe as most vulnerable to flooding i.e, the flood vulnerability map indicates that the university of Jos permanent site, village hostel, Wubyel, Peguna, Congo Rusher, Angwan Rogo, Yan Zuma, and Congo Rusher are most vulnerable to flooding this is because the river has its lower point within those locations. Gangere and British are vulnerable while Dogon Karfe is averagely vulnerable to flooding. This was as a result of the rocky nature of the area and its elevation as represented below.

Table 2 Economic Impact of Flood in the Study Area

Effect of Flood	**Mean**	**Rank**
Loss of farmland	1.66±0.3	1st
Hunger and starvation	1.22±0.4	2nd
Loss of properties	1.21±0.4	3rd
High incidence of poverty	1.20±0.3	4th
Loss of family members	1.19±0.5	5th
Displacement from the natural domain	1.15±1.3	6th
Damage road	1.14±0.4	7th
Causes malaria	1.13±0.4	8th
Adding nutrients to the soil	1.11±0.4	9th
Causes environmental pollution	1.09±0.3	10th

Table 2 indicates the various perceived effects of flood by the farmers in the study area. The effects were categorized as very serious = 2, serious = 1, and not serious = 0. The effects were later ranked in the descending order of their sequence. Loss of farm with a weighted mean score of 1.66 was ranked 1st, hunger and starvation with a weighted mean score of 1.22, loss of properties with a weighted mean score of 1.21, high incidence of poverty (1.20), Loss of family member

(1.19), displacement from the natural domain (1.15). Change in weather which brought about malaria disease (1.13), and flood causing damages on the road with a weighted mean score of 1.14 were perceived as serious economic impacts of flood to farmers in the study area.



(a) Map showing River Dilimi

(b) Map showing River Dilimi and 500 meters buffer

(c) Map Showing points of Agricultural Landuse

(d) Map of flood prone areas along River Dilimi

(e) Map Showing the Topography of The Area

(f) Show the flood vulnerabilit map

Figure 3 Flood vulnerability maps of agricultural landuse along river Dilimi

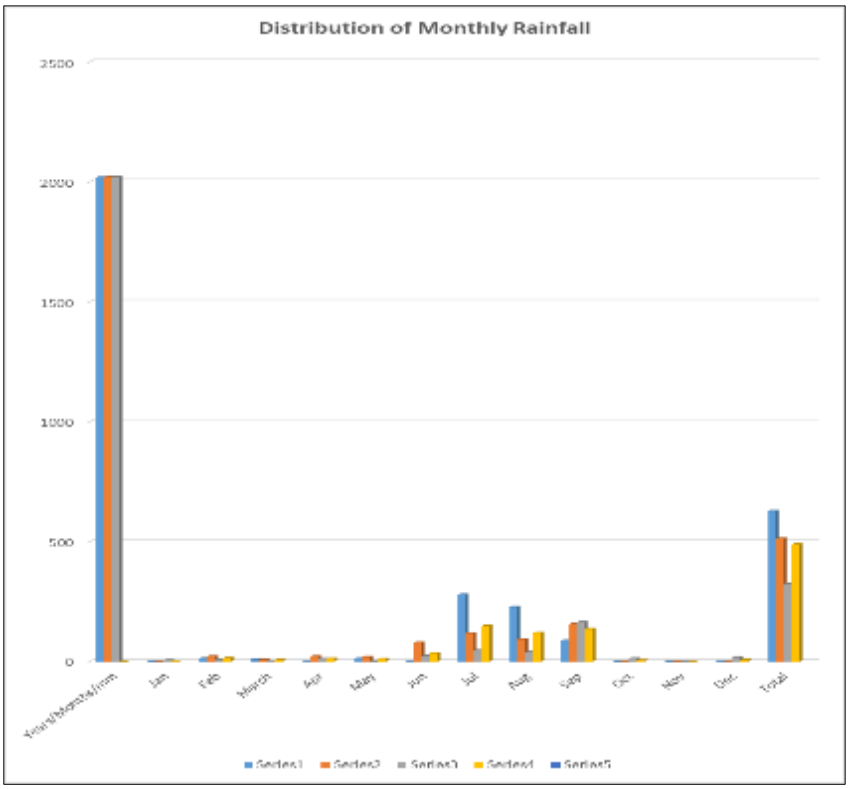


Figure 4 Three Months Rainfall Distribution of the Area

The figure above represents the monthly rainfall distribution within the Jos Plateau state for the period of three years from 2017 to 2019. It was found that the average rainfall for January is 1.53mm, February 13.5mm, March 5.7mm, April 10.9mm, May 9.93mm, June 34.3mm, July 147.1mm, August 119.23mm, September 135.1mm, October 3.97mm, November 0.0mm and December 6.07mm with the total amount of the average from January to December with 487.33mm.

4. Conclusion

The study investigated the impact of flooding on agricultural areas along River Dilimi in Jos North LGA of Plateau State. The study used, high-resolution image and DEM to determine areas vulnerable to floods in the study area. 100 copies of questionnaires were administered to the farmers to identify the economic impact of flood in the study area.

The results reveal that (1.5%) was covered by the area of the river Dilimi, agricultural landuse was made up of (2.82%) and other landuse was made up of (95.66%). The severity of the flood is mostly felt around the lower point along the river and the economic impact is felt by farmers along river Dilimi mostly in the month of July, August, and September as a result of heavy rainfall leading to overflow of the river bank thereby making agricultural landuse areas to submerge and leading to a break in constant crop practice along river Dilimi within the Study area.

The result further revealed that 75% of the farmers were male while the majority (55%) of them were married. The mean age of the farmers was 40 years, while the average farm size was 1.38ha. However, the majority of the farmers 19% lacked formal education, with only 12% having completed basic school and 17% having completed secondary school. Twenty-five percent finished post-secondary education, 14% had vocational training, and 13% had Quranic education. The average year on the farm was 15 years. It was observed from this research that loss of farms, hunger, starvation, displacement from the natural domain, loss of properties, high incidence of poverty, ill health status of the farmers, loss of family members, and causing damage to roads were the major perceived effects of floods on small scale farmers. The study thereby concludes that 46.8%, which is almost half of the study, is susceptible to flooding.

Recommendation

Therefore, farmers are recommended to plant crops that can withstand the pressure of this flood within the months this flood is experienced, workshops on flooding events for farmers in the study area should be held regularly to ensure

that they have a thorough understanding of floods and preventive strategies. Efficient mapping, monitoring, and maintenance of all floodplains, seacoast, natural lakes, and reservoirs (i.e., dams) in Nigeria.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest is to be disclosed

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